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Policy- Driven Water Sector and Energy Dependencies in Texas Border Colonias

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Policy- Driven Water Sector and Energy Dependencies in Texas Border Colonias

by

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Dedication

To my parents for their support throughout this challenging journey. To my husband for all the late night editing and encouragement.

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Abstract

Policy- Driven Water Sector and Energy Dependencies in Texas Border Colonias

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Colonias— a subset of peri-urban subdivisions located in the United States — often lack ease of access to critical infrastructure services, such as water, wastewater, or energy, consequentially cascading into public health challenges and reduced community well-being. This challenge has been tackled globally through differing policy approaches (dependent on location) in attempt to improve the access to such services and the built environment standards existing in these communities. One category of such policy efforts deemed relatively successful is "In-Place Upgrading", requiring local participation of the community residents. In Texas colonias, a statewide law was enacted in 1995 to encourage in-place upgrading. This law, leveraging the prioritization of energy infrastructure in households above other infrastructure services, introduced a logical dependency into communities that required residents—prior to connecting to electricity or gas—to have their platted land registered with the city/county and then connected to adequate water and

wastewater services. This study seeks to assess the relationship between built environment parameters associated with water and wastewater access, and thereby impacting energy access, approximately two decades after the law has been introduced, as well as the perceived burden and efficacy of this particular law on boarder colonia residents. Enabled by publically available data from the Attorney General of Texas Office and semi-structured interviews from state decision makers and promotoras (local community volunteers), hypothesis testing and qualitative methods are used to answer and understand the aforementioned objectives. Three counties—Hidalgo, El Paso, and Cameron—representing 1,297 colonias were used in this analysis. The results revealed that among 110 combinations of parameters exploring colonias access to services and built environment, only one associated pair—colonia incorporation into a city and the presence of a community water system—was present in all three counties. However, many other associated parameters were significance in only one county, indicating the heterogeneity present at the community level when evaluating parameters possibly influencing access to built environment services. Findings from this study suggest decision makers—in addition to those policies and laws in place— focus on localized county/city-level efforts tailored to the community to increase access and improve the built environment.

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INTRODUCTION

Water, wastewater, and energy system are critical infrastructures, of which "whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof" (U.S. Department of Homeland Security, 2017). Colloquially stated, access to these services is necessary for the health and well-being of communities, and as such, when access is limited there may be detrimental consequences. Unfortunately, many of these consequences inequitably fall on vulnerable communities. For instance, rural Alaskan communities lacking access to affordable energy consequentially has resulted in a decrease in household hygiene practices (Eichelberger, 2010). This can also be seen internationally, in Lake Victoria basin (Africa), where the lack of water and energy service required for water and wastewater treatment systems, has resulted in a population with only 53% of access to sanitation in 2006 (Odhiambo et al., 2008).

WATER AND ENERGY SERVICES IN U.S. COLONIAS

Water and energy are intrinsically interrelated. Literature frequently discusses the more obvious interdependencies such as, the use of water to produce hydroelectric power (EPA, 2013; Rio Carrillo et al., 2009), or energy requirements to produce treated drinking water (Barringer, 2015; Webber, 2006). These interdependencies—especially physical interdependencies—are well established at the system scale (Wang, Cao, & Chen, 2017; Moss & Frodl, 2016; Chen & Chen, 2016; Howells & H-holer, 2014; Hussey & Pittock, 2012). However, the (inter)dependencies present at the household level, impacting the individual services received is less discussed. Low-income communities disproportionately

lack access to critical infrastructure services (Brenneman et al., 2002) and are inequitably burdened due to factors such as water poverty (Sullivan, 2002) and energy poverty (Bouzarovski & Petrova, 2015) when receiving such services. Scott et al. (2003) discusses the relationships between energy and water used for cooking, and how intermittent services can interrupt the use of household appliances. As discussed by Dieu-Hang et al. (2017), many of these appliances require resources from both water and energy utilities, such as laundry machines and dishwashers. Due to this water and energy interdependency, the disruption in one resource can affect the other, even at the household level. For instance, Hurricane Maria (in 2017) when making landfall on the island of Puerto Rico resulted in a collapsed electric grid and damaged water infrastructure. With limited utility functionality, rebuilding of *all* water and energy infrastructure is anticipated to take years in remote areas. This in turn has people relying on diesel electric generators that often fail. Without electricity or cooking gas, purifying water (e.g. boiling water) is often limited (Funes, 2018; Dorell & Nuñez, 2017; Hernandez, Leaming, & Murphy, 2017).

Having adequate access is often correlated to the wealth and health of a region (Karekezi Afrepren et al, 2014; Darilek, 2009). Lack of access to water systems and energy infrastructures can be found worldwide (United Nations Department of Economic and Social Affairs, 2015), and as mentioned previously, consequentially, is disproportionally burdensome to vulnerable communities, such as urban slums (Eichelberger, 2010). Notably, urban slums can be found in both developed and undeveloped countries. Although specific attributes of these slums may differ according to geolocation, proximity to cities, or available infrastructure, there are general defining traits (International Bank for Reconstruction and Development & The World Bank, 2008). These traits, according to UN- HABITAT (2006) include: (1) lack of durable housing that is structurally safe and protective against extreme weather conditions; (2) lack of access to adequate sanitation, such as sewer systems and drainage; (3) insufficient living space with no more than three

people sharing a room; (4) lack of easy access to clean a sufficient amount of water at an affordable price; and (5) lack of security of land tenure, due to the government or private agencies owning the houses, which allows for forced evictions. Relevant to this conversation as it develops is that energy access is not included in the defining traits by the UN-Habitat (2006). Further studies, have as such expanded these definitions to include communities that lack access to fixed grid systems, such as electricity and natural gas pipelines for household and community use (Scott et al., 2003) and using fuels that are harmful to health (Bruce et al., 2000). Notably, it is not necessary for a community to exhibit all of these traits to be considered an urban slum.

Of interest to this study are a subset of urban slums known as colonias and more accurately described as peri- urban slums. Peri-urban slums are "[…] housing areas which are peripheral to or marginalized from the formal urban space, but which are not rural…" (Tomar, Patil, & Pandit, 2008). Located in the United States, colonias are primarily located along the international border with Mexico (Davies & Holz, 1992). Colonia is the term in Spanish for neighborhood, defined by The Attorney General of Texas Office (2008) as, "substandard housing developments, often found along the Texas-Mexico border, where residents lack basic services such as drinking water, sewage treatment, and paved roads." Important to point out for this study is that this definition, too, does not include electricity as a metric for defining colonias.

In the United States, colonias development began in the 1950's with low-income people – mostly Hispanic or of Hispanic decent – in search of affordable housing (Federal Reserve Bank of Dallas, 2015; Cisneros, 2001). Small lots – often outside of city limits – that lacked infrastructure and access to publicly provided services were sold for residential purposes (Lyndon B. Johnson School of Public Affairs, 1997). Due to the lack of development and socioeconomic makeup of these communities, residents would (and still

do to present day) often build homes piecemeal (see Figure 1), using various materials and construction methods in a single home (Cisneros, 2001). In the colonias, it is common that residences were initially mobile homes, which were augmented over time to accommodate a growing family (Strickland, 2016).

Figure 1. A colonia home in Hidalgo County; household began as a mobile home, and was expanded upon over time with different construction standards (March, 2018)

Homes in the colonias characteristically lack connections to fixed-grid infrastructure, such as water and wastewater (Jepson & Vandewalle, 2016; TCEQ, 2010). Due to health risks, lack of access to water and sanitation are among the most examined issues in the literature relating to the colonias. A study found that the health of Hispanics that reside in Texas near the border with Mexico are more likely to report fair (29.3% increased rates) or poor (15.5% increased rates) when compared to Caucasians residing in Texas (Anders et al., 2010). Anders et al. (2010) discusses that the lack of public utilities, such as access to potable water and sewer systems in the colonias may exacerbate these health challenges. Similarly, Mier et al. (2008) conducted a study of the health and wellness and quality of life in the colonias as compared to the general population of the United

States, finding three main predictors for mental and physical health challenges present in the colonias. Specifically, lack of access to health services, poor education, and long-term residency in colonias without water and sewer systems. A common thread among these studies is the need to understand the surrounding challenges of residential access to water and wastewater services to aid in health and policy decision-making as it relates to the colonias.

This lack of water and wastewater services and their associated health risks, have attracted the attention of the news media. Several news articles (e.g. Sacchetti, 2018; Gass, 2018; Esquinaca & Jaramillo, 2017; Semuels, 2016a; Strickland, 2016; McGreal, 2015) have found that there is a vast population of people living without the most basic infrastructure including water and wastewater systems, electricity, paved roads and streetlights. These articles also highlight those living in rusted trailers without heat, running water, sanitation or air conditioning. In general, these articles discuss a need for additional government oversight and state policies to enhance infrastructure and utility services in the colonias.

In absence of fixed grid infrastructure, colonias residents have used other methods to receive substitutes for these critical infrastructure services. In the context of potable water supply, water vending machines – known locally as "molinitos" – are used in many colonias (see Figure 2). Previous studies have showed that the high usage of water vending machines is due to the lack of water security in the colonias (Jepson & Brown, 2013; Garcia & Hernandez, 2011). The water security is defined by the UN- Water (2013) as "[t]he capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters…".

(a) (b)

Figure 2. Molinitos in Hidalgo County: (a) Refilling station and (b) Cost of water in December 2017

In the absence of access to fixed-grid wastewater systems, residents often use septic systems. Although frequently used in developed nations in the absence of fixed grid-systems (e.g. rural communities), and not necessary a sign of lack of access, these systems pose health challenges within many colonias. Septic systems are often not adequately maintained and frequently overflow due to poor maintenance and overuse (Semuels, 2016b). Compounding the challenges faced by septic systems are the flooding and corresponding lack of proper drainage, due to quality of the land located in floodplains (Federal Reserve Bank of Dallas, 1996), as during heavy rain events, septic systems are more prone to failure (North Dakota Sate University, 2011). Additionally, septic systems can lead to inadequate wastewater disposal (Reserve Bank of Dallas - Community Affairs Office, n.d.; L. B. Garcia et al., 2016; Cavanagh, 2001), such as disposal by residents in streams, rivers or other body of water (Promotoras, Personal Interview, January 25, 2018). However, in spite of challenges, septic systems are commonly used (Cisneros, 2001; Lyndon B. Johson School of Public Affairs, 1997; Federal Reserve Bank of Dallas, 1996).

Although, not a metric of slums outlined by all institutions (e.g., The Attorney General of Texas, 2008; UN - HABITAT, 2006), access to electricity is discussed in literature as being a relevant characteristic (Scott et al., 2003). While access to water and wastewater has received much attention in the colonias, there has been scarce analysis of the access to electricity and gas infrastructure in the colonias, beyond acknowledging it is in fact a problem (Semuels, 2016a; Strickland, 2016a; Grinberg, 2011). Previous research suggests that the information presented by government agencies indicating that there is no issue regarding electricity access is inaccurate (Olmedo et al., 2013). When not connected to the electric grid, colonias residents tend to connect to the neighbor's through an electrical cord or use gas generators to produce electricity (Olmedo, et al., 2013) . However, it should be noted that, historically, electricity access is higher among residents than water and wastewater access (Promotoras, Personal Interview, May 15, 2017).

Equally diverse to the housing construction and provision of service types (water, wastewater and energy) across different colonias is the jurisdictional areas and regulatory oversight of these services and construction standards (US Department of Housing and Urban Development 2012). Over time, some colonias have been incorporated into cities due to the growth and expansion of both cities and colonias (Durst, 2014). Others remain unincorporated and under the regulation of the county, due to the high costs for cities necessary to alleviate a colonia's infrastructure problems (The Housing Assistance Council, 2010). In some instances, colonias have become cities' extra jurisdictional territories (ETJ's) under the control of both the city and the county, for border colonias five miles away from a city with a population of 5,000 or more (The Office of the Attorney General of Texas, 2008). The jurisdictional sitting of a colonia influences the level of public control over regulations, the amount and origin of funding for infrastructure and public initiatives to improve their conditions (US Department of Housing and Urban Development, 2012; The Office of the Attorney General of Texas, 2008). For instance,

when colonias are incorporated into cities, the building codes enforced by the city are applied to the colonias, as well (Durst, 2014), which in some instances may result in funding infrastructure improvements to meet regulations (HAC Rural Research Report Housing Assistance Council, 2013). In an attempt to improve living conditions in urban slums, including colonias, decision makers have implemented policies and laws, discussed in the following section.

IMPACT OF POLICY ON VULNERABLE COMMUNITIES

Globally, many policy approaches have attempted to improve the standards of, curb the growth of, or eliminate urban slums (International Bank for Reconstruction and Development & The World Bank, 2008). Though no policy is implemented homogeneously throughout the world, most efforts can be classified into five main categories shown in Table 1.

Table 1. General urban slums policy strategies

Policy Strategy	Policy Characteristics	Negative Effects	Positive Effects
Negligence (United Nations Human Settlements Program, 2003)	Negation of the reality of urban slums Urban slums are often not placed on maps, but rather shown as undeveloped land	Postponing addressing community needs will result in higher future costs	None
Forced eviction (United Nations Human Settlements Program, 2003; The International Bank for Reconstruction and Development, 2008)	Forced eviction followed by large scale demolition of urban slums	No alternative living spaces or compensation provided Shifted slums to other areas	None

Table 1, cont.

Clearance and relocation (The International Bank for Reconstruction and Development, 2008)	Removal of residents from slums Residents typically relocated to remote areas	Subsidized land required for relocations Shifted slums to other areas	Relocation compensation provided
Clearance and on- site redevelopment (The International Bank for Reconstruction and Development, 2008)	Temporary removal of residents Clearing land and building new housing such as high-rise low-income apartment buildings	Creation of new housing which is often unaffordable	Housing availability
In-Place Upgrading (The International Bank for Reconstruction and Development, 2008)	Minimizes disturbance to the communities' social and economic life by providing in-situ upgrading Local participation, inclusion of local knowledge for decision making and policy making	None	Community growth and integration Holistic approach to community inclusion in decision making

Urban slums' policy of "In-Place Upgrading"—the primary policy approach used in Texas (Tex. Loc. Gov'T Code Ann. §232.029; West 2016) — is only possible when there is local participation (e.g., residents' involvement in decision making) while simultaneously providing a holistic approach to community inclusion by taking into account health, education, housing, livelihood and gender (The International Bank for Reconstruction and Development, 2008; United Nations Human Settlements Program, 2003). Studies have found that partnerships between local slum residents and governmental agencies allow for a fair representation of community needs in policies implemented in urban slums (de Wit & Berner, 2009; Mathew & Mathew, 2003; Botes & Van Rensburg, 2000).

A report from the International Bank for Reconstruction and Development (2015), found that in order to consider the variability and complexities unique to each urban slum, it is recommended " […] for programs to avoid generalized, top-down approaches. It is always best to go about intervention strategies in a participatory way. Involving households, community based organizations and local Non-Governmental Organizations"

(The International Bank for Reconstruction and Development, 2008). Through participatory efforts, each community can aid in informed decision making about how to best prioritize particular community needs of interest for infrastructure and policy (Laing, 2014). The United Nations Human Settlements Program has used this approach in different countries. An example of this approach is The Orangi Pilot Project in Karachi, Pakistan where over the course of 12 years (1980- 1992), residents built sewers connecting to 72,000 urban slums. The residents affected contributed more than $2 million - an essential aspect of the in-place upgrading approach. As a result of the success of the Orangi Pilot Project, these urban slums now have basic health, family planning, and education. Another example is, the Santo André municipality of São Paulo, which has improved the living conditions of 16,000 favela inhabitants by integrated programs including citizenship, local authorities and aid agencies. These examples demonstrate that this approach is both rewarding and gives the residents a sense of ownership in the improvement of their communities (United Nations Human Settlements Program, 2003).

Deviating from aforementioned worldwide examples of using local or residential labor to upgrade urban slums in-place is using policy and laws—explored in this study—to increase oversight capabilities, essentially forcing communities and developers to upgrade in-place. The governing law relating to border counties in Texas is Subchapter B of Chapter 232, Local Gov'T Code (Tex. Loc. Gov'T Code Ann. §232.029; West 2016). This strategy was motivated by the knowledge that colonias' residents prioritized electricity services over water and wastewater services. This law, introduced in 1995, was intended to increase the residents' connection to water and sewer systems by requiring water and sewer connections at the parcel level *before* a resident could receive electricity (Tex. Loc. Gov'T Code Ann. § 232.029; West 2016). Interestingly, as mentioned previously, electricity is not a metric used to identify urban slums by The Attorney General of Texas, (2008) and the UN - HABITAT (2006). However, access to electricity was

determined to be an incentive to increase access to the services that lack thereof were associated with the poor quality of life and health challenges present in these communities, namely water and wastewater. As such, electricity access is a focal point—in addition to water and wastewater access—throughout the conversation presented in this study.

Subchapter B of Chapter 232 of the Texas Local Government Code (LGC), enacted in 1995, revamped regulatory requirements for platting within boarder colonias (Tex. Loc. Gov'T Code Ann. §232.029; West 2016), including measures for assuring access to water and sewer service, and conversely, restrictions on the sales of lots—platted or not—that lack such water and sewer services. Initially the jurisdictional area of Subchapter B applied to 17 counties (1995-1998) that were areas of high unemployment and low-income areas. This was amended in 1999 to cover 28 counties, and once more in 2005, bringing the total to 29 counties within 50 miles of the boarder (The Attorney General of Texas, 2008c). Notably Subchapter B is applied to subdivisions of two or more residential lots outside of city limits and outside of the extraterritorial jurisdiction of any municipality (Tex. Loc. Gov'T Code Ann. §212.001, §232.029; West 2016; The Attorney General of Texas, 2008d).

The intention of this code is to "improve the quality of life for residents" of colonias through improved access to infrastructure services, primarily focusing on the provision of water and wastewater service, integration of health and safety infrastructure, and halting the increase of colonias (Texas Secretary of State, 2003). Notably, through improving the built environment in this classification of communities, if such efforts are effective, the corresponding number of colonias should decrease as the preexisting and new communities will no longer meet the aforementioned criteria of a "colonia".

In general, this law introduced logical dependencies (Rinaldi et al., 2001) in to the boarder colonias, restricting access of residential infrastructure services until criteria was met (see Figure 3). Upon subdividing land, the plat must be registered with the city or country, receiving a certificate (Certificate of Compliance). Upon receipt of this certificate, a utility may then—assuming conditions are suitable for such services, such as the presence of network or the home is up to necessary codes for connection—subsequently, connect water and sewer services. Post water and sewer connection, electricity and gas may be connected to the plat (Tex. Loc. Gov'T Code Ann. §232.029; West 2016). Exceptions may apply as outlined in the Texas Local Gov'T. Code.

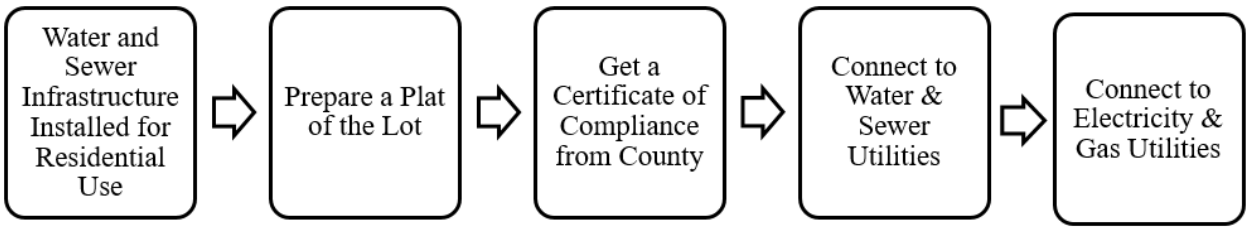

Figure 3. Logical dependencies introduced to boarder colonia via Subchapter B of Chapter 232 of the Texas Local Gov'T Code

The OAG Lead Colonias Investigator (Personal Interview, October 10 2017) discussed that Subchapter B was created as an incentive to improve connections to water and sewer via reprioritizing the provision of these services at household level. Prior to this law, electricity and gas was prioritized above connecting to water and wastewater. By introducing this dependency, in order receive electricity or gas, it was required that "…adequate water and sewer services have been installed to service the lot or subdivision" (Tex. Loc. Gov'T Code Ann. §232.029; West 2016). Although the sale of new colonia subdivisions had increased oversight by the local government as compared to prior,

residents with non-platted lots obtained before 1995—often lacking critical infrastructure—did not fall under this law. Thus, an amendment was introduced in 1997 (The Attorney General of Texas, 2008b), which created the "hardship exception" that "…generally allowed a utility already serving one lot in a subdivision to serve other lots sold on Sept 1, 1995, on which construction was begun by May 1, 1997" (Tex. Loc. Gov'T Code Ann. § 232.029 (c)(1); West 2016)

The Colonias Initiative Program under the Office of the Secretary of State, initiated in 2005 (Texas Secretary of State, 2003), was tasked to "establish and maintain a statewide classification system, to track state–funded projects related to water/wastewater, road paving and other assistance to colonias" (Tex. S.B. 827, 72th Leg., R.S., 2005). This program was dissolved in 2017, with the final report prepared for legislature in 2014 (Texas Office Of The Secretary Of State, 2014).

This study seeks to answer the following questions: *(1) What built environment parameters are associated with access to water and wastewater in Texas boarder colonias (and as a results of the logical dependency, impacts energy services)? (2) Are the parameters associated with access to water and wastewater the same across counties? (3) What is the perceived efficacy and burden of this law, approximately two decades later?*

Enabled by data from (Texas Office of Attorney General, 2015) and semi-structured interviews with local colonia residents and decision makers, hypothesis testing explores the relationship between existing conditions of the colonias and access to services, as well as the perceived efficacy and burden of the increased oversight introduced by Subchapter, Chapter 232 of Texas Local Gov'T Code. Outcomes of this study include the relationship between living conditions parameters, such as access to water, wastewater and energy services, in three Texas counties (Hidalgo, El Paso, and Cameron).

METHODOLOGY

Using hypothesis testing and semi-structured interviews, this study aims to understand the implications of logical dependencies (Rinaldi et al. 2001) introduced by design—i.e. dependencies intentionally introduced via policy or laws between the water, wastewater, and energy services received at the household level. Specifically of interest is understanding the implications of a law— Subchapter B of Chapter 232 of the Local Gov'T Code in Texas (Tex. Loc. Gov'T Code Ann. §232.029; West 2016)— aimed at creating dependencies at the parcel level, in which residents must meet requirements regarding platting and water and wastewater connections prior to connecting to electricity and gas in the household (Figure 3).

CHI- SQUARE TEST OF INDEPENDENCE

The Chi-Square Test of Independence evaluates whether a significant statistical relationship exists between two nominal variables (McHugh, 2013). This hypothesis test is used to explore the statistical relationship of paired variables related to the access to water, wastewater, and other built environment characteristics (e.g. presence of paved roads, access to a health clinic, community located in a floodplain) in border colonias; these variables are summarized in Table 2. A colonia was designated No/Yes if a selected characteristic is present, corresponding to a binary variable, 0/1. The disparity in reporting is a result of data collection from different government agencies.

Table 2. Selected variables from used in chi-squared test

Data (The Attorney General of Texas, 2015)	Significance of data for this study
Has a plat been prepared? (No/Yes)	Having a prepared plat will allow for the residents to acquire Certificates of Compliance for utility connections as stated by Subchapter B of Chapter 232, Texas LGC
Is the community incorporated or within an incorporated area? (No/Yes)	Select colonias have been incorporated into cities, which consequentially results in increased funding opportunities for infrastructure (The Office of the Attorney General of Texas, 2008; US Department of Housing and Urban Development, 2012)

Table 2, cont.

Colonia Classification (Red/Green/Yellow/Unknown)	The classification system provides information on the state of infrastructure within the colonias in regards to providing water or wastewater services, paved roads, among others
Public distribution of water? (No/Yes/Partial)	Distribution systems of public drinking water supplies: pipes and other conveyances that connect treatment plants to consumers' taps If answered yes, water distribution infrastructure exists and colonia residents are connected or have access to water connection (Collected by the SOS)
Private wells? (No/Yes/Partial)	Private wells allow for access to water without additional infrastructure such as water pipes If sufficient water is extracted from wells, there may not be a need for a connection to water utilities. (Collected by the SOS)
Is water hauled in? (No/Yes/Partial)	There is no central water system and no wells present Residents fill water tanks in vending machines (molinitos) or buy water in convenience stores and transport it home
Is wastewater collection available? (No/Yes)	Wastewater collection systems that gather wastewater from homes and take it to a wastewater treatment plant. Aggregates wastewater infrastructure systems and septic systems; having access to wastewater collection available is indistinguishable as to if that access is via infrastructure system or septic system
Is there a community water system? (No/Yes)	Water infrastructure proved by private, public or non-profit water utilities (Collected by the TWDB)
Do all lots have potable water? (No/Yes)	Answers to whether all lots in each colonia have potable water Does not consider whether there is partial potable water within a colonia
Is the community in a floodplain? (No/Yes/Partial)	Indicates susceptibility to flooding
Are the roads paved? (No/Yes/Partial)	Presence of paved roads
Is there water supply from wells? (0/1)	Presence of wells supplying water for all homes in a colonia (Collected by the SOS)
Is there a project to improve water service to the community? (0/1)	Projects can come from different sources such as the County, the State, or a neighboring city If a colonias has recently been incorporated to a city, then most often than not, the city will fund improvements
Is there a wastewater collection private? (0/1)	Wastewater sewage system privately owned. Aggregates wastewater infrastructure systems and septic systems; having access to wastewater collection available is indistinguishable as to if that access is via infrastructure system or septic system
Health clinic access? (No/Yes)	Presence of a health clinic; indicator of public health resources
Is there a community wastewater collection system? (0/1)	This can include wastewater infrastructure system or septic tanks. Aggregates wastewater infrastructure systems and septic systems; having access to wastewater collection available is indistinguishable as to if that access is via infrastructure system or septic system

SEMI- STRUCTURED INTERVIEWS

In order to explore the perceived relationship between water, wastewater, and energy residential access post the introduction of the 1995 law– Subchapter B of Chapter 232, Texas LGC (Tex. Loc. Gov'T Code Ann. §232.029; West 2016)– semi-structured interviews were conducted with decision-makers, as well as community residents (interviews conducted summarized in Table 3). A semi-structured interview provides some structure based on the research but works flexibly by allowing respondents spontaneous descriptions and moves with the narrative. Twelve semi-structured interviews were performed in 2017 and spring 2018 that were approximately 60 minutes in length, two interviews (i.e. Promotora # 2 and District coordinator, Field Response Section in Table 3) were each six hours long due to the interviewees and interviewer visiting colonias around Hidalgo in person. This data collection process was used to "provide complex textual descriptions of how people experience a given research issue" by collecting personal histories, perspectives, and experiences (Mack, 2005). Interviews were conducted using established guidelines with interviewees selected using criteria for good informant selection for ethnographic interviews (Spradley, 1979). Snowball sampling was used to locate and contact knowledgeable individuals regarding the law or via experience living in the communities. Interviews conducted with the decision makers spanned topics such as the expansion of colonias and enforcement of laws within the colonias. Interviews conducted with promotoras— colonias outreach volunteers who reside in the colonias— were related to their personal experiences with their water, wastewater and electricity utilities and interaction with the government officials regarding connection to utility services after the introduction of this law. A fluent speaker, dependent on the cultural background of the interviewee, conducted the interviews in either English or Spanish. Notably, during data collection, one focus group (indicated as such in Table 3) was conducted to " [… allow] researchers to learn the social norms of a community or subgroup,

as well as the range of perspectives that exist within that community or subgroup" (Mack, 2005).

Table 3. Interviewees

Interviewees	Position	Time in position/ Time living in colonias	Date Interview Conducted
OAG Austin Colonias Prevention Office	Lead Colonias Investigator	Present	October 10, 2017
Hidalgo County Planning Department	Director of Planning	2015- Present	October 20, 2017
El Paso County Attorney	Assistant County Attorney	2003- Present	October 27, 2017
Hidalgo County Drainage District 1	Hidalgo County Drainage District No. 1 General Manage	Present	December 12, 2017
Texas Division of Emergency Management	District coordinator, Field Response Section (Hidalgo County)	Present	December 11, 2017
Texas A&M University, Colonias Program	Regional Director- Lower Rio Grande Valley	Present	May 15, 2017
The SOS Colonias Initiatives Program	Director of Colonia Initiatives Program	Unknown- August 31, 2017	September 26, 2017
Promotora #1	Hidalgo County Promotora	18 years	May 15, 2017
Promotora #2	Hidalgo County Promotora	10 years	May 15, 2017 January 25, 2018
Promotora #3	Hidalgo County Promotora	15 years	January 25, 2018
Focus Group (3 People)	Hidalgo County (Promotoras- Members of the Community)	More than 10 years each	January 25, 2018

CASE STUDIES

Three different Texas border counties were selected for this study, specifically Cameron, Hidalgo, and El Paso (refer to Figure 4) to ensure that the results didn't reflect

that of a specific colonia or county. These counties were selected due to differing characteristics such as population and geographic location in Texas with the border to Mexico (see Table 4). Hidalgo County contains the largest population living in colonias in Texas; Cameron and El Paso have the highest number of colonias after Hidalgo County.

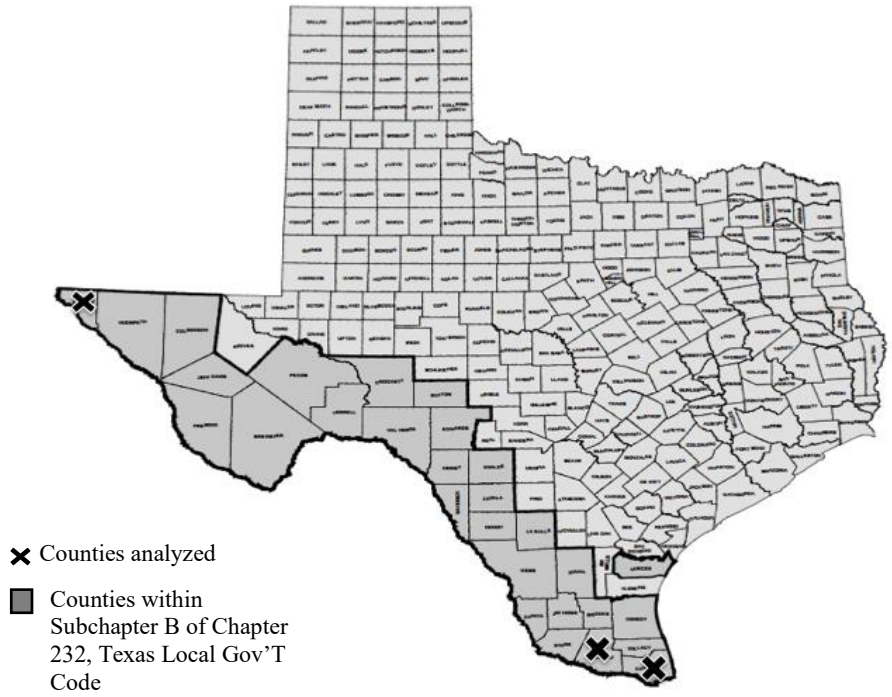

Figure 4. Case study counties from left to right: El Paso, Hidalgo, and Cameron; shaded counties represent the border Texas counties that apply for Subchapter B of Chapter 232, Local Government Code (Texas Office of the Attorney General, 2008).

Table 4 provides information regarding the population of the colonias considered in this study and the number of colonias classified by The Colonias Initiative Program (Texas Office of the Secretary Of State, 2014). The Secretary of State Office (SOS) Colonias Initiative Program classified Texas colonias into four categories, based on access to services (electricity not considered in classification), specially:

- Green colonias, which have access to potable water systems, paved roads, and operational wastewater disposal systems.

- Yellow colonias with existing potable water service (via wells or either public or private water systems) and an approved wastewater disposal system but which lack adequate paved road, drainage, or a solid waste disposal system, posing an intermediate health risk.
- Red colonias that lack basic infrastructure such as potable water, functional wastewater disposal, or platted subdivisions (defined below).
- Unknown colonias that the status could not be determined.

Table 4. Colonias characteristics (Texas Office of the Attorney General, 2015)

County	2000 colonias population	Total number of colonias	Number of green classified colonias	Number of yellow classified colonias	Number of red classified colonias	Number of unknown classified colonias
Cameron	33,564	172	91	40	41	0
Hidalgo	135,139	818	262	225	105	226
El Paso	49,210	292	165	34	56	37

DATA

With more than 500,000 residents residing in over 2,200 colonias, Texas has the most colonias and highest population of colonia residents in the country (Federal Reserve Bank of Dallas, 2015; Garcia & Hernandez, 2011; Larson, 2002). According to a 2015 Colonias Report by the Federal Reserve Bank of Dallas (2015), more than 40 percent of colonias residents live below the poverty line, making less than $24,250 for a family of four (Office of the Assistant Secretary for Planning and Evaluation, 2015).

To evaluate the current state of the built environment in the colonias, a database from the Texas Office of the Attorney General (OAG, 2015) was compiled, bringing together information from The Texas Water Development Board (TWDB), The Texas Secretary of State (SOS), and The Texas Office of the Attorney General (OAG). The

database (OAG, 2015) summarizes 73 questions regarding water, wastewater and other characteristics of colonias (e.g. whether the colonia is platted at the time or not, if the colonia has access to a health clinic, among others). For this study, 16 criteria related to water, wastewater, and other built environment characteristics were considered across the three counties (see Table 2 for parameters used in this study). Six of the evaluated criterion included an additional dimension, yielding No/Yes/Partial. In some instances, colonias were evaluated as an aggregate. For example, a No/Yes designation was given to an entire colonia when evaluated for "Do all lots have potable water?" Criteria pertaining to colonias, which were not evaluated by government agencies in all instances, is represented as "unknown" or blank data and were omitted from analysis.

The methods for the provision of services categorized by the Texas Office of the Secretary of State (2015) within the colonias are as follows: public distribution of water via a fixed-grid infrastructure system (Figure 5); water hauled via colonias residents from "molinitos" or other sources (Figure 6); and private wells (Figure 7) .

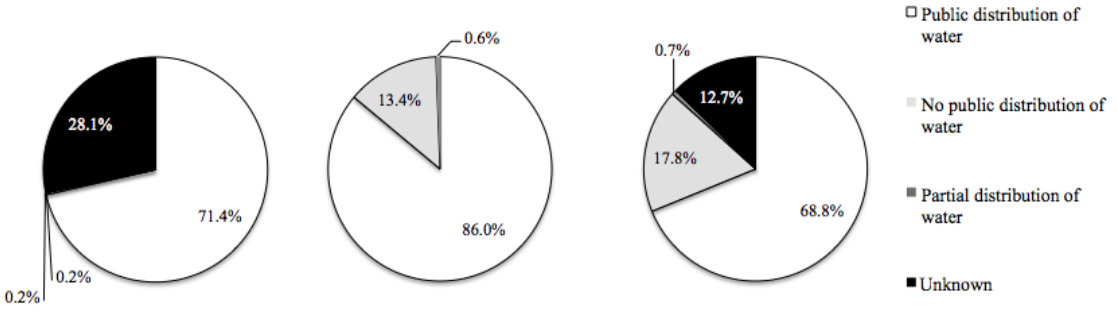

Figure 5. Provision of water services via water distribution system in colonias be county (Texas Office of Attorney General, 2015): (a) Hidalgo; (b) Cameron; and (c) El Paso

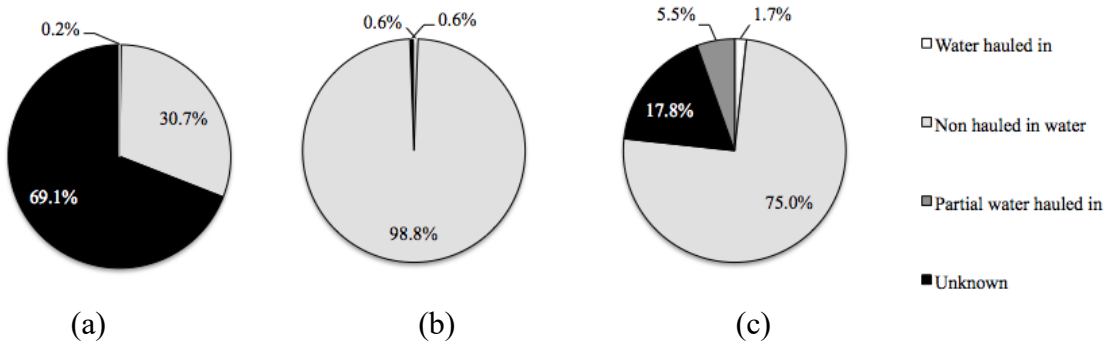

Figure 6. Provision of water services via water hauled in colonies by county (Texas Office of Attorney General, 2015): (a) Hidalgo; (b) Cameron; and (c) El Paso

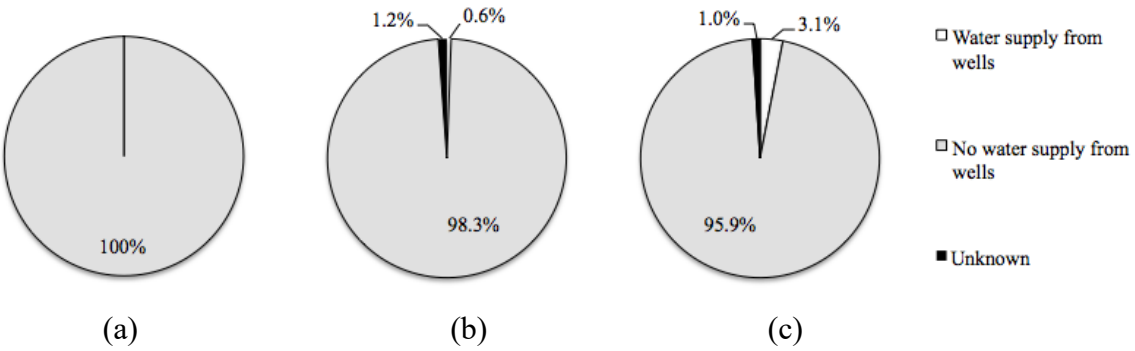

Figure 7. Provision of water services via private wells in colonies by county (Texas Office of Attorney General, 2015) (a) Hidalgo; (b) Cameron; and (c) El Paso

Data available regarding wastewater access via the OAG (2015) aggregates wastewater infrastructure systems and septic systems, and as such, colonias coded as having access to wastewater collection available are indistinguishable as to if that access is via infrastructure system or septic system (Figure 8). Notably, Subchapter B of Chapter 232, Local Gov'T Code (Tex. Loc. Gov'T Code Ann. §232.029; West 2016) recognizes septic systems as an option for wastewater service/connection, which is the primary alternative to wastewater infrastructure connections used in these communities (Federal Reserve Bank of Dallas, 1996). However, this law does not recognize hauling water as an acceptable alternative to water access, although a primary method used in colonias to

access potable water, and as such, distinguishes and desegregates the methods (Tex. Loc. Gov'T Code Ann. §232.029; West 2016).

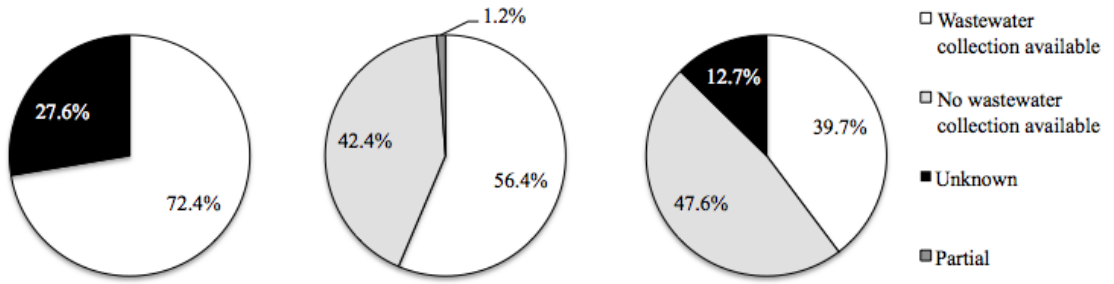

Figure 8. Wastewater collection access in colonies by county (Texas Office of Attorney General, 2015) (a) Hidalgo; (b) Cameron; and (c) El Paso

Limitations to this study include lack of data availability in the colonias, a limitation widely discussed in previous studies (Olmedo et al., 2013; Mier et al., 2008). Publically available data (The Attorney General of Texas, 2015) is from 2015 post the introduction of the law. Thus, as a result, a temporal comparison cannot be conducted, as comprehensive condition data was not gathered prior to 1995. To fill this gap, semi-structured interviews and literature provide insight into the conditions before 1995 and the present-day (2018) perceived burdens. Additionally, semi-structured interviews were only conducted in Hidalgo County; however, this is the county with the highest colonia population in Texas (Barton et al., 2015).

The most notable limitation is that information regarding current and past energy (electricity and gas) infrastructure, as well as connections to services at the parcel-level are not available to the author's knowledge as of April 2018. Semi-structured interviews were used to fill in knowledge gaps of access to this infrastructure and provide a holistic understanding. It should be noted, that in spite of the absence of this quantitative data, the

results still provide useful information. The dependency was introduced with the intention of only allowing energy access after other criteria used to define urban slums/colonias were adequately met as residents sought out and prioritized access of energy (Personal Interview, Promotora, May 15, 2017; Personal Interview, OAG Lead Colonias Investigator, October 10, 2017). Thus, those with access to water and wastewater, under most circumstances have access to electricity and gas services (Personal Interview, Promotoras, January, 25 2018). Understanding the barriers to meeting the first two criteria, platting and water and wastewater services, provides insight into factors impacting the holistic access of infrastructure services, including electricity and gas, as these are needed prior to receiving electricity and gas.

RESULTS & DISCUSSION

Prior to Subchapter B of Chapter 232, Texas Local Gov'T Code in 1995, colonia residents prioritized electricity at the household level for air-conditioning and communication appliances over water and wastewater services (El Paso County Attorney, Personal Interview, October 27, 2017; Hidalgo County Promotoras, Personal Interview, May 15, 2017). Electric utilities previously did not have requirements for connection, such as construction standards or proof of meeting local regulatory requirements, determining connection/disconnection based on payments received (Hidalgo County Promotoras, Personal Interview, May 15, 2017). Typical to low-income communities experiencing rampant energy poverty (Mimmi, 2014; Mimmi & Ecer, 2010; Energy Sector Management Assistance Program, 2007), if electricity is too burdensome for a resident, they may—knowingly or unknowingly to the neighbors—connect to neighboring electricity lines illegally, routing live wire to their lots (Promotoras, Personal Interview, May 15, 2017). Notably, such electricity theft is not necessarily curbed by the introduction of laws, and may even, in some circumstances, increase such thefts by decreasing the ease of access to this prioritized utility service. Furthermore, it is important to note that if energy poverty is the driver of lack of access for a resident, it is likely that water poverty is also a challenge, and by requiring both services, may in essence create challenges for utility access in that it is "all or nothing" to receive electricity service sought.

Before 1995, methods were anecdotally shared in which residents adapted lifestyle to accommodate lack of water and sewer services, such as purchasing drinking water from convenience stores or molinitos (Figure 2) and disposing of wastewater into streams (Promotoras, Personal Interview, May 15, 2017). Consequentially, this lack of access can cascade to detrimental public health and environmental impacts for the community and surrounding communities. For instance, in the mid-1990s the colonias in Texas discharged

almost 2 million gallons per day of untreated wastewater into the Rio Grande River (Cavanagh, 2001).

The three critical infrastructure services – water, wastewater, and energy – logically dependent resulting from Subchapter B of Section 232, Texas Local Gov'T Code, are discussed herein. Platting is discussed within these three critical infrastructure services due the requirement by law to have a prepared plat before gaining access to these services. Multiple counties are integrated into the analysis due to the law discussed applying to all border counties in Texas and to ensure that the results are not framed solely by the enforcement or oversight of one county, local policies, or local cultures, accounting for the heterogeneity across geographic regions.

In spite of the restrictions placed by the introduction of this law, it was discussed with promotoras that colonia residents with or without access to the services as outlined above, acquire gas tanks from convenience stores for household use (Promotoras, Personal Interview, May 15, 2017). In the context of gas, acquisition has been perceived to be limited by income and not impeded by platted land connections. However, in the context of electricity, it was discussed that lack of access to electricity is not uncommon, partially due to this law, as well as other factors like energy poverty. Consequentially, residents seek other, off-grid sources, including fuel powered electric generators or a homemade connection to the neighbor's electricity. As electricity is the highest priority utility service for those who can afford access, first requiring access of water and wastewater services, incentivizes such connections. Thus, understanding the parameters that are associated with access to water and wastewater, in turn, provide information on the parameters associated with electricity access.

Table 6 shows the results of the chi- squared test. Each paired- combination variable of the colonias' built environment with statistical significant association is presented by

county. Three different statistical significance levels are shown to understand the level of impact Subchapter B, Chapter 232, Texas Local Gov'T Code had on each county and associated paired parameters. When understanding the results of the chi-squared test, it must be kept in mind that the database is a compilation of data collected by different agencies, and, as expected data may differ based on interpretation or data collection method. For example, the SOS tracks the presence of public water distribution systems, solely, whereas the TWDB tracks the presence of private, public, or non-profit water distribution systems within the colonias (Texas Water Development Board, 2018), referred to as community water system. Consequentially, the associated parameters may differ dependent on the classification of water distribution system access. The data discrepancies may be a result of SOS requirements to monitor state-funded programs to improve the colonias, including public water distribution systems (Texas Office Of The Secretary Of State, 2006). In contrast, the TWDB has a program for assisting in the upgrading colonias infrastructure called "Economically Distressed Areas Program" (EDAP), that provides financial help to "…disadvantage political subdivisions, cities, counties, water districts and non- profit water supply corporations…" (Texas Water Development Board, 2018). For these reasons, the two agencies fundamentally require different tracking of program funding. Another example that will be present throughout the discussion is the difference in data collection regarding water wells. Access to wells measured by the SOS is only in regards to private wells and the TWDB collected data on access to private or public wells with no distinction.

Table 6. Chi Square Results

*p < 0.01 **p < 0.05 ***p < 0.1	Has a plat been prepared?	Is the community incorporated or within an incorporated area?	Colonia classification	Presence of public distributio n of water?	Presence of private wells?	Is water hauled in?	Is wastewater collection available?	Is there a community water system?	Do all lots have potable water?	Is the community in a floodplain?	Are roads paved ?	Is there water supply form wells?	Is there a project to improve water service to the community?	Is there private wastewater collection?	Health clinic access	Is there a community wastewater collection system?
Has a plat been prepared?																
Community incorporated	*Hidalgo															
Colonia classification	*Hidalgo, *Cameron	*Hidalgo														
Presence of public distribution of water?																
Presence of private wells?		*Cameron														
Is water hauled in?																
Is wastewater collection available?	*Cameron	*El Paso	*Cameron	*Cameron	**Cameron											
Is there a community water system?		**Cameron *Hidalgo, *El Paso	*Hidalgo		*El Paso	*El Paso	*El Paso									
Do all lots have potable water?		*El Paso						*El Paso								
Is the community in a floodplain?		*Hidalgo	*Hidalgo, *Cameron				***El Paso	*Hidalgo, *El Paso	*El Paso							
Are roads paved?		**Hidalgo								**Hidalgo						
Is there water supply from private wells?			*El Paso						***El Paso							
Is there a project to improve water service to the community?			*El Paso													
Is there private wastewater collection?		*El Paso	*El Paso				*El Paso ***Cameron	*El Paso, *Cameron	*El Paso	***El Paso						
Health clinic access		*Hidalgo	*Hidalgo				*Cameron	*Hidalgo			**Hid algo					
Is there a community wastewater collection system?		**Hidalgo, *El Paso	*El Paso				*El Paso	*El Paso, ***Cameron	*El Paso	*Hidalgo, ***Camero n		***El Paso		*El Paso		

ACCESS TO WATER SERVICES

When classifying the colonias into green, yellow, red, and unknown, the SOS determined colonias to have access to water via wells or either public or private water systems. Notably, Subchapter B of Chapter 232, Texas Local Gov'T Code, makes no mention regarding hauled water but for the purpose of this study hauled water will be considered as an alternative for water service due to frequent use in colonias.

Regarding the colonias' living conditions affected by the provision of water service, post the introduction of Subchapter B of Chapter 232, Texas Local Gov'T Code, this study assessed access to water through the following services: public water distribution system (data collected by the SOS), community water distribution system (data collected by the TWDB), hauling water (data collected by the SOS), private wells (data collected by the SOS), and private/public wells (data collected by the TWDB). Table 7 summarizes the chi-squared results each county's provision of water methods in the respective colonias, showing the statistically significant association between parameters (p- values) and a dash were no statistically significant relationship exists.

Access to a community water system (TWDB) – public, non-profit, or private – is associated with whether the colonia is incorporated into a city (Hidalgo— $p < 0.01$, El Paso— $p < 0.01$, Cameron—$p<0.05$). This is consistent with previous studies that have identified that colonia incorporation into a city improves the standards of living (Durst, 2014; HAC Rural Research Report Housing Assistance Council, 2013). For example, when a colonia gets incorporated into a city, the construction of water lines and wastewater treatment plants is funded by the city (The Housing Assistance Council, 2010). An additional example supporting this improved quality of life is that in *non*-incorporated colonias, funding for roads, trash, and infrastructure maintenance is not provided by cities

(The Housing Assistance Council, 2010). Therefore, residents in non-incorporated colonias often organize to find outside funding or fund their own infrastructure maintenance (Promotoras, Personal Interview, May 15, 2017; Hidalgo County Emergency Manager, Personal Interview, December 11, 2017).

In contrast, public distribution of water (as described by the SOS) is associated only with access to wastewater collection service ($p < 0.01$) in Cameron County. This highlights the heterogeneity across counties, and may be capturing local prioritization of the presence (or lack thereof) of having both systems or local culture. Additionally, this may be capturing local government oversight enforcement or efforts that differ from other counties.

An alternative to water infrastructure systems is the use of wells. Either private or community wells provide colonia residents with water, assuming such wells meet adequate water quality standards. According to data collected by the Texas Office of Attorney General (OAG, 2015) and by account of the promotoras (Promotoras, Personal Interview, January 25, 2018), Hidalgo County does not use private wells for water service, and unsurprisingly, this chi-square test showed no association to other parameters. Colonias having access to water supply from wells is only associated with three parameters in El Paso County. Colonia classification is the most significant with a corresponding p-value of < 0.05 versus the remaining parameters of having potable water ($p < 0.1$) and community wastewater connections ($p < 0.1$). Even though wells may be a reliable source of water, many colonias residents prefer to haul water in, due to the high costs of building wells (Promotoras, Personal Interview, January 25, 2018). This is supported by data from the Texas Office of Attorney General (OAG, 2015) that shows a larger percentage of colonias' residents hauling water than using wells. As expected, hauling water is only associated with one parameter in El Paso - whether a community water system exists ($p < 0.01$). These relationships with water systems presence is not unexpected, as if there is a water system

present, the necessity for hauling in water or installing wells is often negated, and the chi-square test does not indicate correlation, just the presence of a relationship. Thus, upon further assessment, these communities that do have systems, are less likely to need substitute services.

These results demonstrate that in regard to the provision of water services and the parameters associated with them in the three counties, colonias may benefit from a more localized policy approach (exemplified by the lack of patterns found among associated parameters across counties), such as in other urban slums in-place upgrading approaches used by the UN- Habitat (United Nations Human Settlements Program, 2003) and The World Bank (The International Bank for Reconstruction and Development, 2008). In El Paso County, colonias with an existing community water system show three unique statistically significant relationships to other parameters, whereas Hidalgo and Cameron counties revealed one and zero associations, respectively (Table 7). This suggests El Paso County would benefit from enabling community water system policies that include relationships with private wells ($p < 0.01$), wastewater collection systems ($p < 0.01$) and with water hauling ($p < 0.01$). The access to community water systems in Cameron and Hidalgo counties do not show significant relationships with these three parameters, and would not stand to benefit from said policies relating to El Paso County. The analysis suggests that Hidalgo County would benefit from policy encompassing colonias of all classifications (Red, Yellow, Green, Unknown) relating to the access community water systems.

By localizing the approach of public distribution of water into three counties, decision makers can understand what factors may affect colonias access to public distribution of water and target efforts specifically designed for the local population as has been shown successfully in urban slums. As shown in Table 6, presence of a public water

distribution system in Cameron County colonias' is associated with wastewater collection availability ($p < 0.01$). Accounting for this, future policy should be structured to address both these issues within one policy. Local population can contribute in the prioritization of critical infrastructure and give feedback on how to effectively accomplish this task, in a mutually beneficially manner. For example, all colonias might consider water access as the number one priority, but in each county (and even in each colonia) approaches may vary from constructing a nearby water treatment plant to adding more public wells, depending on individual community needs.

Notably, the data gathered by OAG (2015) does not consider molinitos as an adequate method to receive drinking water, thus, this preferred method of drinking water by colonias, needs to be examined separately from other provisions of water services. In an initial interview, promotoras disclosed that residents, even when connected to water systems, prefer acquiring drinking water from molinitos rather than tap water, due to water suppliers providing low-quality water of which residents do not drink (Promotoras, Personal Interview, May 15, 2017). This observation is consistent with previous studies (e.g. Jepson & Brown, 2014; Garcia & Hernandez, 2011) that have concluded the success of molinitos is due to the lack of trust in water quality form utility providers. Consumer perception of water utilities is a key aspect of the state- public relationship (Dowler et al., 2006), and commitment by the state (i.e. utility or service provider) to building a relationship founded on trust is critical to the end-user (Haider et al., 2016; Han et al., 2015; Morgan et al., 2011). According to the U.S. Environmental Protection Agency (2018) water distribution systems in the colonias have had many administrative (e.g. clerical), and water quality violations. In the first quarter of 2018, utilities serving colonias in El Paso and Hidalgo counties each had approximately 200 violations and Cameron County had approximately 400 violations in water quality and reporting failures (United Sates Environmental Protection Agency, 2018).

In addition to lack of quality in water services hindering drinking water access, is the presence of water poverty. Despite some communities having access to water, many residents cannot afford to maintain the connection (Promotoras, Personal Interview, May 15, 2017). This array of possible reasons why people in colonias lack access to on-demand quality drinking water shows that a localized policy in improving water quality or economic help should be established depending on the root cause for that particular community.

One striking and unexpected result, as this data was collected post-introduction of Subchapter B of Chapter 232, Texas Local Gov'T Code, revealed that plat preparedness was independent of all methods for the provision of water services (Table 7). This may be a result of differing goals of agencies that is reflected in differing data collected. For instance when considering access to water infrastructure systems, the SOS considered only publicly managed water systems, whereas the TWBD considered, and gathered data on publically, privately or non- profit managed water systems. Importantly to note, these partnerships increase access to valuable data. Additionally, these partnerships between agencies, whether private or public, allow for bringing in experts of different backgrounds (Wakeman, 1997b) that are needed to enhance the objectives serving public service (Mitchell, 1990). Due to the electricity service dependency on water service, parameters previously mentioned to be associated to the provision of water as well as with the plat preparedness, will have a cascading effect on electricity. For example, in for all three counties incorporation to a community shows a statistical relationship to the access of a community water system.

Semi-structured interviews regarding the burden of Subchapter B of Chapter 232, Texas Local Gov'T Code with promotoras and decision makers align in the general views

that water services are improving. This has been primarily attributed to increase in funding opportunities aimed at improving infrastructure in colonias (Promotoras, Personal Interview, May 15, 2017; Hidalgo County Director of Planning, October 20, 2017; Hidalgo County Emergency Manager, Personal Interview, December 11, 2017). Notably, promotoras perceive that colonias further from cities have relatively worse water conditions (Promotoras, Personal Interview, January 25, 2018). This might suggest that official oversight resources in remote areas are still in need of improvement.

Table 7. Breakdown of the associated parameters with the different method for the provision of water by county

	Colonia class-ification	Community incorporated	Private Wells	Waste-water collection available	All lots with potable water	In a flood-plain	Waste-water collection is private	Health clinic access	Community wastewater system	Water supply from wells	Water hauled in	Community water system
Hidalgo County												
Public distribution of water (SOS)	-	-	-	-	-	-	-	-	-	-	-	-
Community water system (TWDB)	p< 0.01	p < 0.01	-	-	-	p<0.01	-	p < 0.01	-	-	-	-
If the water is hauled in	-	-	-	-	-	-	-	-	-	-	-	-
If there are private wells (SOS)	-	-	-	-	-	-	-	-	-	-	-	-
Water supply from wells (TWDB)	-	-	-	-	-	-	-	-	-	-	-	-
Do all lots have potable water	-	-	-	-	-	-	-	-	-	-	-	-
El Paso County												
Public distribution of water (SOS)	-	-	-	-	-	-	-	-	-	-	-	-
Community water system (TWDB)	-	p < 0.01	p <0.01	p < 0.01	p < 0.01	p < 0.01	p < 0.01	-	p < 0.01	-	p <0.01	-
If the water is hauled in	-	-	-	-	-	-	-	-	-	-	-	p <0.01
If there are private wells (SOS)	-	-	-	-	-	-	-	-	-	-	-	p <0.01

Table 7, cont.

Water supply from wells (TWDB)	p <0.05	-	-	-	p <0.1	-	-	-	p <0.1	-	-	-
Do all lots have potable water	-	p < 0.01	-	-	-	p < 0.01	p < 0.01	-	p < 0.01	p <0.1	-	p <0.01
Cameron County												
Public distribution of water (SOS)	-	-	-	p < 0.01	-	-	-	-	-	-	-	-
Community water system (TWDB)	-	p < 0.05	-	-	-	-	p < 0.01	-	p < 0.1	-	-	-
If the water is hauled in	-	-	-	-	-	-	-	-	-	-	-	-
If there are private wells (SOS)	-	p < 0.01	-	p < 0.05	-	-	-	-	-	-	-	-
Water supply from wells (TWDB)	-	-	-	-	-	-	-	-	-	-	-	-
Do all lots have potable water	-	-	-	-	-	-	-	-	-	-	-	-

ACCESS TO WASTEWATER SERVICES

When classifying the colonias into green, yellow, red, and unknown, the SOS determined colonias to have access to wastewater via wastewater system or septic systems. Notably, Subchapter B of Chapter 232, Texas Local Gov'T Code, specifically states that wastewater and septic systems are both adequate methods of wastewater access (Tex. Loc. Gov'T Code Ann. §232.029; West 2016). Notably, the presence of wastewater *access* includes access via septic systems. When discussing solely fixed-grid wastewater infrastructure systems, this is referred to as wastewater infrastructure systems.

The literature shows that in general, wastewater systems in colonias tend to be less prominent than public water systems (Cavanagh, 2001). Access to wastewater collection systems is only associated with the public distribution of water in Cameron County ($p < 0.05$; Table 10). This is supported by data (Texas Office of the Attorney General, 2015) indicating that the majority of colonias in Cameron County have both public distribution of water and wastewater collection available (Table 8), which may be a result of effective laws and policy (the data does not indicate when the systems were installed, and thus, this relationship may be independent or pre-date this law), or may be localized priorities and culture. Nonetheless, *how* Cameron achieved this, should be further explored. This is also true in Hidalgo County, where 71% of colonias have public water distribution systems, and 72% have community wastewater collection services; however, these variables are not associated. Nor were variables associated with El Paso systems, where 68% colonias have a public water distribution system versus 39% having wastewater collection systems. Thus, this supports that the results may be capturing localized conditions, as opposed to purely the presence of, or lack thereof, systems, and warrants further exploration in Cameron into effective methods to create interdependencies, if this is the goal of future policies

Table 8. Relationship between the public distribution of water and wastewater collection system (does not include septic systems) availability in Cameron County

Cameron County		Wastewater collection system available	
		Yes	No
Public distribution of water	Yes	90 (53.25%)	56 (33.14%)
	No	7 (4.14%)	16 (9.47%)

In the case of wastewater, both the SOS and the TWDB have a different metrics to measure wastewater infrastructure system access. The TWDB distinguishes wastewater infrastructure system access from private and community. The SOS does not distinguish between privately or publically managed wastewater infrastructure systems. As mentioned before, this may be due to different interests between agencies to monitor access of services in colonias, and further highlights the challenge of data related to these communities. For this study, the distinction for private versus public does not matter, and is not considered in the discussion.

Notably, whether the colonias are in a floodplain is associated with access to wastewater services in all counties (Table 10). For Cameron, being located in a floodplain is associated with access to wastewater services ($p < 0.1$). In El Paso, being located in a floodplain is associated with the presence of wastewater infrastructure systems ($p < 0.1$) and the presence of private wastewater infrastructure systems ($p < 0.1$). In Hidalgo County, whether a colonia is located in a floodplain is associated with the presence of wastewater infrastructure systems ($p < 0.01$). Impacts from flooding to wastewater utilities include loss of power and damage to assets such as pipes (United States Environmental Protection Agency, 2014). Flooding can occur at the level of utilities as well as residential areas. At the utility level, “sanitary sewage overflow” occur when the flow of water exceed the capacity of the system (Golden, 1996; Strifling, 2003). News media have cover stories relating that when flooding occurs, wastewater utility discharge partially untreated water

into rivers due to overcapacity of wastewater treatment plants (Biolchini, 2018; Burgio, 2018). At the household level, flooding can cause corrosion in pipelines and cause them to break (Abbott, 2016). This can lead into environmental hazards as well as sanitary hazards for residents. Even though all counties revealed associations between floodplains and the presence of wastewater infrastructure systems, each county should have a separate flood in wastewater mitigation plan due to difference in terrains and weather representative geolocation (United States Environmental Protection Agency, 2014; Golden, 1996).

Literature shows that septic systems are the most commonly used method of colonias wastewater systems even though they are usually inadequately constructed or improperly maintained (Rural Community Assistance Partnership (RCAP), 2015; Federal Reserve Bank of Dallas, 1996). In flood prone areas, septic systems are more prone to failure (North Dakota Sate University, 2011) and overuse of septic tanks can cause residents to discharge wastewater and waste into streams (Reserve Bank of Dallas - Community Affairs Office, n.d.; L. B. Garcia et al., 2016; Cavanagh, 2001). Interestingly, with commonly used septic systems, overflow is cited as a recurring issue, further exacerbated by unpaved roads that hinder water drainage and are prone to flooding (Promotoras, Personal Interview, January 25, 2018). This challenge between septic overflows and drainage is not unique to colonias, documented in urban slums around the world, resulting in paved roads becoming a priority for aid programs (The International Bank for Reconstruction and Development, 2008).

In this analysis, Hidalgo County is the only county exhibiting a significant relationship between location of a floodplain and paved roads ($p < 0.05$). Interestingly, according to the data (Texas Office of the Attorney General, 2015) most of the colonias in Hidalgo County with paved roads are not located in floodplains (Table 9). As the minority

of the colonias in Hidalgo County are both located in a floodplain and do not have paved road, at just 4.43%, it is within reason that construction of this infrastructure is achievable.

Table 9. Relationship between paved roads and location in a floodplain of colonias in Hidalgo County

Hidalgo County		Paved Roads	
		Yes	No
Located in a floodplain	Yes	(28.55%)	(4.43%)
	No	(59.04%)	(7.98%)

Having a prepared plat and having access to water and wastewater infrastructure regulates electricity access in colonias. Surprisingly, only Cameron County has an association between the presence of wastewater infrastructure systems and plat preparedness ($p < 0.01$, Table 10). This shows that understanding the electricity access can benefit from a county-to-county policy and data collection. Subchapter B of Chapter 232, Texas Local Gov'T Code has a perceived burden in wastewater access similar to water access. According to promotoras, colonias located farther from cities tend to have a less likelihood of having access to wastewater services (Promotoras, Personal Interview, January 25, 2018). It is the role of promotoras to work as a conduit, communicating colonia needs to appropriate governmental authorities for support, such as identifying infrastructure needs. However, colonias residents are often skeptical to seek such due to fear of legal residency status (Promotoras, Personal Interview, May 15, 2017; Hidalgo County Emergency Manager, Personal Interview, December 11, 2017)

Table 10. Breakdown of the associated parameters with the different method for the wastewater service by county

	Plat pre-pared	Colonia class-ification	Community incorporated	Private Wells	Waste-water collection available	All lots with potable water	In a flood-plain	Waste-water collection is private	Health clinic access	Community wastewater system	Water supply from wells	Community water system	Public water system
Hidalgo County													
Wastewater collection available (SOS)	-	-	-	-	-	-	p<0.01	-	-	-	-	-	-
Private wastewater collection (TWDB)	-	-	-	-	-	-	-	-	-	-	-	-	-
Community wastewater collection (TWDB)	-	-	p<0.05	-	-	-	-	-	-	-	-	-	-
El Paso County													
Wastewater collection available (SOS)	-	-	p<0.01	-	-	-	p<0.1	p<0.01	-	p<0.01	-	p<0.01	-
Private wastewater collection (TWDB)	-	p<0.01	-	-	p<0.01	p<0.01	p<0.1	p<0.01	-	-	p<0.1	p<0.01	-
Community wastewater collection (TWDB)	-	p<0.01	-	-	p<0.01	p<0.01	-	-	-	-	-	p<0.01	-
Cameron County													
Wastewater collection available (SOS)	p<0.01	p<0.01	-	p<0.05	-	-	-	p<0.1	p<0.1	-	-	-	p<0.01
Private wastewater collection (TWDB)	-	-	-	-	p<0.1	-	-	-	-	-	-	p<0.1	-
Community wastewater collection (TWDB)	-	-	-	-	-	-	p<0.1	-	-	-	-	p<0.1	-

ACCESS TO ENERGY SERVICES

Due to the already discussed consequential impact on energy access arising from water and wastewater access, it is important to synthesize the parameters associated with water and wastewater access. Notably, Hidalgo County has no associated parameters regarding water services and wastewater services. This may indicate that electricity in Hidalgo County is associated to other built environment characteristics not evaluated here, such as the proximity to an electric grid. El Paso and Cameron counties exhibit statistically significant relationships between water service and wastewater collection access. These parameters can be seen in Table 6 and are listed below in Table 11:

Table 11. Breakdown of the associated parameters between methods for provision of water and wastewater access in El Paso and Cameron counties

	Wastewater collection available (SOS)	Private wastewater collection (TWDB)	Community wastewater collection (TWDB)
El Paso County			
Community water system (TWDB)	$p < 0.01$	$p < 0.01$	$p < 0.01$
Water supply from wells (TWDB)	-	-	$p < 0.01$
Do all lots have potable water	-	$p < 0.01$	$p < 0.01$
Cameron County			
Public distribution of water (SOS)	$p < 0.01$	-	-
Community water system (TWDB)	-	-	-
Water supply from wells (TWDB)	-	$p < 0.01$	-
If there are private wells (SOS)	$p < 0.05$	$p < 0.01$	$p < 0.1$

Notably, El Paso County and Cameron County both have wastewater collection associated with water supply form wells with $p < 0.01$ in both cases. The other provisions of water services differentiate between counties. Even though this difference exists, it is clear that provision of water has an associated relationship with the wastewater collection availability. This relationships should be explored for future policies involving energy access.

Having a plat prepared is another determinant to energy access, resulting from Subchapter B of Chapter 232, Texas Local Gov'T Code. Surprisingly, El Paso County showed no association with plat preparedness and other parameters evaluated here (Table 6). Cameron County is the only county indicating an association between access to wastewater collection system and plat preparedness. The difference in the combination of parameters and their statistical relevance suggests each county should have localized policies that support and focus on local efforts. As there is a lack of data collection efforts relating to energy in colonias, an opportunity exists to evaluate the services provided and how policy can favor access to colonias lacking energy services.

Semi- structured interviews with promotoras and decision makers provided anecdotal evidence pertaining to the availability of access to energy services in the colonias. The promotoras disclosed that despite an increase in access to energy services in general across colonias, there are still many colonias without electricity. Some of these colonias without electricity service are dependent upon gas generators to supply homes with power. Similar to other utility services, the lack of access appears to be more prevalent in rural/remote colonias (Promotoras, Personal Interview, January 25, 2018). Additionally, promotoras consider there to be a distinct difference between access to electricity service, and current connection capabilities to electricity utilities. An additional variable hindering access to energy services for colonia residents is energy affordability coupled with low-

income socioeconomic status; these challenges are not addressed by the law of interest to this study. However, interviews revealed decision-makers perceived a successful increase in access to electricity utility services in recent years due to policy efforts (Hidalgo County, Director of Planning, Personal Interview, October 20, 2017; OAG Lead Colonias Investigator, Personal Interview, October 10, 2017). No data has been collected to date (known to the author) differentiating current electricity connection capabilities in a community versus having access to electricity service at parcel level whether due to barriers in place due to laws or energy poverty. This revealed a lack of fundamental understanding between the relationship of utility services and factors affecting access. Particularly, there is a lack of understanding if the implemented law is impacting utility services, or if energy poverty (and water poverty) is causing the current lack of connection which would necessitate different intervention strategies aside from the former policy/laws.

Due to plat preparedness being required by law (Tex. Loc. Gov'T Code Ann. §232.029; West 2016), the person selling newly subdivided land is responsible for this process. With some exceptions, semi- structured interviews with promotoras revealed that colonias residents do not experience many burdens getting a plat prepared (CITE). One of the commonly experienced burdens is in instances where older- existing colonias without previously platted land are faced with obtaining a plat. These residents having to plat their lots themselves cannot afford the costs, or do not have the existing water and wastewater infrastructure required by law. Another commonly experienced burden relating to plats is when land is purchased in remote areas, the buyer is unaware of the requirement that platted-land be connected to water and energy services. When purchasing land, the law favors the purchaser, as it is the seller's responsibility to plat the land. Colonias residents are often unaware that they can ask for help, or are reluctant to do so because of their immigration status. The Texas Office of the Attorney General (OAG) confirmed this

finding, stating when notified by the resident buyer of an issue regarding platting, the OAG will initiate an investigation to identify and hold accountable the culpable party – the seller.

CONCLUSIONS

Water, energy, and wastewater are critical infrastructures necessary for community health and well-being. Low-income communities tend to be disproportionately affected by access to these seemingly basic services. Different policy approaches have been implemented around the world in efforts to increase access to services. Of interest to this study is a subset of urban slums, colonias, more accurately describe as peri-urban slums, which are substandard communities on the U.S.-Mexico border. In 1995, Subchapter B of Chapter 232, Texas Local Gov'T Code was introduced with the intent to upgrade critical infrastructure by enforcing access to water and wastewater systems as a prerequisite for energy services. This study sought to understand, two decades post the introduction of this law, the built environment parameters associated with water and wastewater access in the colonias, and as an indirect result due to this dependency introduced via law, access to electricity. To provide context and understanding of the impact of this law, in terms of efficacy and perceived burdens, semi-structured interviews were conducted with decision-makers and promotoras. Data spanned three counties – Hidalgo, El Paso, and Cameron—and 1,297 colonias in the state of Texas, which is home to a majority of the colonia population in the U.S. Chi-squared analyses indicated heterogeneity across associated built environment parameters manifesting in various counties, possibly due to factors such as differing regulatory enforcement, local culture and prioritization, and geographic locations. The lack of patterns among associated parameters across counties suggests that each county has been affected differently by Subchapter B of Chapter 232, Texas Local Gov'T Code. For instance plat preparedness shows no association with any provision of water services and only with Cameron County's wastewater collection system. Additionally, water hauled in is only associated with other water services within El Paso County. Notably, city incorporation of colonias was associated with 14 parameters for all three countries, indicating, that as supported in literature (Durst, 2014; HAC Rural Research Report

Housing Assistance Council, 2013), this does improve living standards of colonia residents due to increased oversight provided by the city.

Subchapter B of Chapter 232, LGC has provided the foundation for improving quality of life for the colonias, however further improvements are needed to achieve the intended end result. Policies, which are tailor-made for each county's colonias, will further improve living conditions. Promotoras have reported improvements stemming from funding efforts, which aid colonias with improvements, such as infrastructure and health services. Government officials and promotoras interviewed concur that there have been improvements to colonias' living conditions resulting from policy efforts. Testimony by the promotoras indicates despite these efforts, colonias are still far-removed from the standard of living experienced by city residents. In contrast to this, government officials believe that the colonias have the resources to become city-incorporated. Despite the best efforts of government officials to mitigate the growth of colonias, promotoras disclosed that the colonias continue to expand. In some instances, this new growth is not documented, such as in new and future maps, resulting in off-grid colonias. Establishing a uniform-definition of colonias, recognized by government officials will allow for colonias to be addressed more directly in future policy making decisions, rather than a one-size-fits-all approach to vulnerable communities. A suggested definition of a colonia is as follows: "Colonias are peri-urban, U.S.-Mexico border communities lacking any of the following built environment characteristics: having a prepared plat of land, homes designed and constructed to withstand the elements, paved roads and proper storm water drainage, access to public or private water distribution system, access to sewer system connected to a wastewater treatment plant, connection to electricity, or access to health services."

Identifying the challenges unique to each county may drive changes in policy relating to colonias. One of the key components of this work is revealing the lack of a

universal definition of colonias and its' implications. A partnership between agencies is valuable for resilient decision- making (Wakeman, 1997a). Establishing a uniform definition can increase the efficiency mitigation of colonias expansion by allowing tailor-made policy specific to the border colonias. Another contribution, not documented before this study, is the effort to understand the effects of policy-created dependency on quality of life for residents of the colonias. By incorporating hypothesis testing and semi-structured interviews with community leaders and statewide decision makers, it was revealed that a more comprehensive and continuous data collection program, and an agreed-upon definition for colonias should be the basis of future policy work.

Policy-makers in the State of Texas should construct a streamlined metric in which components of the built environment for all colonias are quantified. Establishing this metric will allow for a more uniform and robust data collection system amongst agencies invested in the well-being of the colonias. Data regarding colonias infrastructure and access to services should be updated annually in order to observe the positive or negative effects of current policies and make informed decisions using the data. Moreover, it is important to for policy-makers to make concerted efforts for improving localized policy rather than state-wide all-encompassing policy solutions.

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